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CAPE COD IN ITS RELATION TO THE MARINE FLORA OF NEW ENGLAND.

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(Plate 134.)

THE first to call attention to Cape Cod as a dividing point, or demarcation area, in the marine flora of the Atlantic coast of North America was William Henry Harvey (1852, p. 24). In his introduction to Part I of the *Nereis Boreali-Americana*, the first account of the North American algae to be published, Harvey divides the eastern coast of North America into four divisions, as follows:—"First, the coast north of Cape Cod, extending probably to Greenland; second, Long Island Sound, including under this head New York Harbor and the Sands of New Jersey; third, Cape Hatteras to Cape Florida, and fourth, Florida Keys and shores of the Mexican Gulf." This division of our eastern coast by one who had collected over a greater extent of it than any one previous to his writing and even more than scarcely any collector of algae since his time, and who had before him a very considerable collection of marine algae from the coasts of the entire world, carries with it the greatest conviction and has withstood most admirably the test of time. The chief difference between our present point of view and that of Harvey lies in the tendency to divide again the coast from Cape Cod north into two or three divisions. The position assigned by Harvey to Cape Cod is much the same in our present considerations.

Farlow (1881, p. 4), in his *New England Algae*, also emphasizes the relation of Cape Cod as a demarcation point between the marine flora to the north and that to the south of it. Farlow, however, calls

attention to the fact that Cape Cod does not sharply and exactly divide the northern from the southern marine flora of New England and proceeds to add much to our knowledge by discussing the reasons for this imperfect division. He says (loc. cit. p. 3, et seq.):—"If we regard the marine vegetation of the northeastern United States as a whole, we see that, beginning at Eastport, we have a strongly marked arctic flora, which is a direct continuation of that of Greenland and Newfoundland. As we proceed southward towards Boston, although the luxuriance of growth is less, the general appearance of the flora is still unmistakably arctic, if we except a few sheltered localities. The northern shore of Cape Cod, from its sandy character, is practically destitute of all species of algae, except a few forms which are here and there found growing on the eelgrass. As soon as we pass to the south of Cape Cod, however, the flora assumes an entirely different aspect. The arctic and Northern European forms have disappeared, except at a few exposed points like Gay Head and Montauk, and in their place, we find a number of species, as *Dasya elegans*, *Rhabdonia tenera*, *Chondria tenuissima*, *Sargassum vulgare*, characteristic of warmer seas." A little farther on, he goes on to say:—"It will be seen that Cape Cod is the dividing line between a marked northern and a southern flora. In fact, the difference between the florae of Massachusetts Bay and Buzzards Bay, which are only a few miles apart, is greater than the difference between those of Massachusetts Bay and the Bay of Fundy, or between those of Nantucket and Norfolk. This difference in the flora corresponds precisely with what is known of the fauna. That Cape Cod formed a dividing line was known to Harvey, and subsequent observation has only shown, on the one hand, that the flora north of Cape Cod is more decidedly arctic than he supposed, and that, on the other hand, south of the Cape it is more decidedly that of warm seas. The general fact of the distinctness of the two florae is not weakened by the knowledge that we now possess, owing to the investigations of the Fish Commission, of the existence in a few sheltered localities north of Cape Cod of some of the characteristic species of Long Island Sound and, in a few exposed spots south of the cape, of northern species. Of the more common species found along the whole coast of New England, by far the greater part are also common in Europe. . . . But a very few exclusively American species are found throughout our limits. Most of the purely American species are either confined to the shore south of Cape Cod or else to the shore from Boston northward."

In the paragraphs just quoted, Farlow has clearly stated the general relation of Cape Cod to the marine florae of New England. It is clearly the dividing point, but not exact in separating the northern from the southern flora. There are certain species passing over it from north to south and certain other species passing over it from south to north. He adds by way of explanation that the southern species are found in "a few sheltered localities north of Cape Cod" and that the northern species occur "in a few exposed spots south of the cape." As examples of the latter he mentions Gay Head, Massachusetts, and Montauk Point on the eastern extremity of Long Island. He also speaks of Block Island as well as Gay Head as having cold waters and speaks of a characteristic northern species (*Ptilota serrata*) as occurring in reduced form at the Thimble Islands, near New Haven in Long Island Sound. As to "sheltered localities north of Cape Cod," he describes particularly Goose Cove, in the town of Gloucester, near the village of Squam, and makes the remark:—"If we compare the exceptional cases of Goose Cove in the north with Gay Head and Montauk in the south, it seems to be the rule that wherever the water is cold enough, we meet arctic species, and wherever it is warm enough we have Long Island species, regardless of the remoteness of localities where the species naturally abound, and as far as we know, of the absence of currents to transport the spores" (loc. cit., p. 7).

Finally, I may call attention to the remarks of Farlow (loc. cit., p. 6) contrasting the general aspects of the two florae on the New England coast. They are as follows:—"If north of Boston the principal feature of the marine vegetation is the enormous mass of large *Fuci* and *Phaeosporae*, the *Florideae* forming an insignificant part of the flora, the chief feature of the flora south of Cape Cod is the preponderance of *Florideae* and the comparative insignificance of the *Fuci* and *Phaeosporae*". I may add that later studies have emphasized this distinction and have shown that the larger *Fuci* and *Phaeosporae* associations found south of Cape Cod, occur without exception at colder spots and may be looked upon as invasions from the north.

Frank S. Collins, who was long identified with the study of the marine algae of New England and whose knowledge of its species and their habits far surpassed that of any other botanist, made many contributions towards determining the exact relation of Cape Cod to the marine florae of the coast on which it is situated. Besides many papers relating to new species, species new to the coast of New England,

etc., in which there are many details closely related to the topic I am discussing, he published (1900) a list of the marine algae of New England with distribution noted as to the shores of the different states. I quote from his introductory note, as follows:—"Massachusetts . . . is divided into two parts, northern and southern, as the most strongly marked division line for algae on the whole Atlantic coast occurs here. As regards the marine flora, Nahant and Nantucket differ more from each other than the former does from Newfoundland, or the latter from Fortress Monroe. The division line is usually given as Cape Cod but as the flora of the inside of the lower cape is the same as that of Vineyard Sound, the latitude of Provincetown has been taken as the boundary." For the preparation of this paper, Mr. Collins took the trouble to prepare an extended and annotated list, bringing the published list up to present date and adding notes as to habitat and localities for the majority of the species. It seems safe to assert that the flora of the coast of New England is better and more definitely known than that of any coast of similar extent and diversity, and that much of this is due to the efforts of Mr. Collins. I have, therefore, a feeling of the greatest confidence in undertaking the discussion of the geographical distribution of the marine flora of this coast as a model and precedent for similar discussions of the same problem for other and less known coasts. I desire, accordingly, to express here my sincere indebtedness to Mr. Collins for his generosity in turning over for my use of so much valuable data.

Besides the publication of the "list," Collins has called attention to some of the very definite and important warm spots to the north of Cape Cod, all of which have been either discovered or, at least, personally investigated by him. In 1908, Collins especially mentioned three distinct areas of warm spots, viz. . . . those about Quincy and Weymouth, Massachusetts, those about Gloucester, Massachusetts, and those in the vicinity of Casco Bay, Maine. He states that in early warm spring seasons, there are abundant southern forms in these warm spots, while in late cool seasons, southern forms are scarce.

The biological survey of the waters in the vicinity of Woods Hole, Massachusetts, carried on by the U. S. Fish Commission under the direction of Francis B. Sumner and Bradley M. Davis during the years 1903-1905, have been published in excellent form for yielding the greatest assistance to the student of the geographical distribution of the marine flora of New England. The report (1911) on this

work covers the coast from Buzzards Bay to the shoal waters off and above Chatham, Massachusetts. This region is a mixture of enclosed shallow waters, exposed points, and intruding deeper waters and the flora is, in consequence, a mixture of northern and southern species. The data given and the charts of the detailed distribution of the individual species are sufficiently numerous to indicate very exactly the difference in the distribution of the two types of species. In the report of Davis, on the marine algae of the district, we have the definite proof of the statements of Farlow and of Collins.

My own collecting along the coast of New England has been more or less extensive and in 1893, I made a reference to Cape Cod as a dividing line in the kelp-flora of the eastern coast of North America. I also made the statement (1893, p. 370) that the isotherm, or line of mean maximum temperature of the surface waters of the north Atlantic Ocean, for 20° C., touched the shore in its neighborhood. The paper of 1893, although dealing only with the Laminariaceae or kelps so far as distribution is concerned, has opened up the larger question of climatic distribution in general for all organisms and paved the way for the papers on the geographical distribution of the marine algae published in 1915, 1917 and 1920. Through the data afforded by demarcation areas such as that of Cape Cod, but situated on all coasts throughout the world, I have divided the photic belts of the neritic shelves of the coasts of the world into climatic zones according to mean maxima of the surface waters. For reasons which I have given elsewhere, it has seemed most natural to establish nine climatic or temperature zones extending from the far north to the extremes of marine plant life in the south and these, with the exception of the two polar zones may be considered to be limited by surface isotherms 5° C. apart. The coast of New England is divided between the North Temperate Zone, between the isotherms of 15° C. and 20° C. and the North Subtropical Zone, between the isotherms of 20° C. and 25° C. The question, therefore, of the relation of the 20° C. isotherm to Cape Cod is vital to any discussion of the climatic zones as I have attempted define and delimit them.

In checking over and tabulating the species of marine algae of New England so kindly and generously provided by Mr. Collins, I find that there are 551 species, varieties, and forms at present to be accredited with some considerable certainty to the coast. Of course, there is some uncertainty in a few cases, but apparently less so than

is the case for most floras. I think that this source of probable error may be discounted without any considerable concern. Of these 551 species, etc., 136 are credited only to the north of Cape Cod, 113 only to the south of it, while 302 are credited to both sides of it. In other words, species, etc., exclusively north amount to about 24.5 per cent. of the whole number, those exclusively south to about 20.5 per cent., and those passing the Cape in one direction or the other to nearly 55 per cent.

The first interest naturally centers in the 302 species, or approximately 55 per cent. of the whole number of species concerning whose exact nature as to whether they may belong more normally with the northern or with the southern group it is desirable to have farther information. Careful examination into the details of occurrence of these species enables one to separate them into their respective groups, only 12 being clearly uncertain and needing more careful study from this point of view to determine their exact status. By removing from the 290 species remaining, those which occur south only in colder waters or which appear or fruit only in the colder seasons, we are able to feel certain that 132, or about 43 per cent. of those generally distributed, are normally northern species. Adding these 132 to the 136 species found only north of Cape Cod, there result 268 which may perhaps seem normally northern. On the other hand, if, in a similar way there are removed from the 302 generally distributed species, the 12 doubtful ones and then those which occur north only in the warm spots or warmer situations, there are found to be 158 of these and this number added to the 113 which are credited only to the south of Cape Cod gives 271 as presumably normally southern. These figures seem to indicate that the number of species, varieties, etc., is approximately the same for each flora.

It might seem that the figures given above were sufficiently accurate and explicit to indicate the exact nature of the situation on the coast of New England, but a careful consideration of the details of the conditions under which the species accredited only to the north exist there, shows that 37 of them occur in warm localities and are presumably to be considered as normally southern. Probably they will be found south of the cape at some future date. As to why they have not as yet been found south may be due to several reasons, viz. incomplete exploration, lack of suitable habitat, scarcity, etc. It must be borne in mind that the shores south of Cape Cod are more largely

sandy and there is a general lack of the bold cliffs so characteristic of the northern shores of New England. If the 37 seemingly southern species are subtracted from the northern list, there remain 99 seemingly true northern species in it.

In a similar way, careful consideration of the list of species yields a surprise by showing that 30 of the 113 species credited only to the south are found solely in localities of colder waters or appear or fruit only in the colder seasons. This leaves 83 species to be regarded as normally southern. The details of the various segregations are given on the accompanying table which shows that 261 species, etc., may be regarded as belonging to the colder waters and 278 to the warmer waters, while 12 are to be placed in the doubtful column for the present at least.

TABULATION OF SPECIES, VARIETIES, FORMS, ETC., OF MARINE
ALGAE OF THE NEW ENGLAND COAST.

N. of Cape Cod—	Total	Normally N.	Normally S.	Uncertain.
Myxophyceae.	26	4	22	
Chlorophyceae.	29	17	12	
Melanophyceae.	40	37	3	
Rhodophyceae.	41	41	0	
Total.	136	99	37	
S. of Cape Cod—				
Myxophyceae.	18	1	17	
Chlorophyceae.	19	3	16	
Melanophyceae.	37	17	20	
Rhodophyceae.	39	9	30	
Total.	113	30	83	
N. and S. of Cape Cod—				
Myxophyceae.—	56	8	47	1
Chlorophyceae.	68	22	44	2
Melanophyceae.	73	48	17	8
Rhodophyceae.	105	54	50	1
Total.	302	132	158	12
Final Total.	551	261	278	12

These figures, and other deductions which may be drawn from the table, show that Cape Cod does not appear to be so distinctly a dividing line as might have been supposed from the statements of the various authors, yet the general character, or appearance of the flora, especially as seen in the litoral belt, is very different north of Cape Cod

from what it is below. The reasons for this are as have been noted that the conspicuous *Fucus*- and *Laminaria*-associations of the north shores are, to some considerable extent, represented all along the rocky coasts and are more or less conspicuously situated in the literal or upper sublitoral belts, while to the south, these associations occur but seldom and scattered, and the *Laminaria*-associations, in particular are well down in the sublitoral belt and consequently, seldom seen.

The remaining question to be raised and, if possible, answered, is as to the exact relation of Cape Cod to the isotheres of 15° C. and 20° C. and, consequently its situation as to the North Temperate and the North Subtropical Zones. The normal or dominant marine flora north of the cape is clearly that of the North Temperate, intermingled with the floras of the Lower and Upper Boreal Zones as seasonal invasions. The normal or dominant flora of the Long Island Sound district is just as clearly that of the North Subtropical Zone. If Cape Cod is not the strict dividing line, as appears certainly to be the case, where is that dividing line and what is its relation to Cape Cod? The isothere of 15° C. strikes the coast a little to the north of New England and its relations to the coast itself are somewhat complicated. It is sufficient for our present purpose, however, to say that it is far north of Cape Cod. The isothere of 20° C., on the other hand, is represented on the temperature charts as coming toward land some miles west of Montauk Point at the eastern extremity of Long Island. Taken literally, then, the Cape Cod peninsula is situated well within the North Temperate Zone. An examination of the charts of this portion of the New England coast, however, and of such temperature data as are available, show that the isothere of 20° C. bends eastward in an irregular sort of a way, to include at least the more or less enclosed and shallow waters of the easternmost corner of Long Island Sound, Narragansett Bay, Buzzards Bay, Vineyard or Nantucket Sound and the Nantucket Shoal up the neighborhood of Chatham on the outer Cape Cod peninsular (cf. Setchell, 1915, p. 296). The influence of the warmed up water of these shallow and more or less enclosed areas is doubtless felt some appreciable distance out beyond their boundaries, but exposed points like those at Gay Head, outer coast of Rhode Island at Newport, Point Judith and Watch Hill, Block Island, and the eastern end of Long Island Sound at Montauk Point, vicinity of New London

(exposed to the full outer temperature through the inward cold currents of "The Race") are, and ought to be expected to be provided with waters of a temperature of 20° C. or less. Even if these portions of the coast are somewhat affected by the warmer waters from within, the deeper waters are colder and, consequently, we find that the northern species are frequently found in water of one to thirteen or more fathoms in these areas, whereas north of the cape the same species may occur in the litoral, or at least in the uppermost sublitoral belt. It seems that there is a scanty northern flora in the deeper waters even of the interior of Long Island Sound itself.

I have prepared a map showing the probable details of the deflection of the 20° C. isotherm inwards and its enclosure of the inland waters eastward from its approach to land from the outer waters. It passes along the coasts of eastern Connecticut outer coasts of Rhode Island, and southern and southeastern coasts of Massachusetts, and its position illustrates the general relation, at least, of Cape Cod to this 20° C. line of mean maximum temperature. This map and its temperature lines show that the district between Chatham, Massachusetts on the east and New London and Montauk Point on the west, belongs to the North Subtropical Zone so far as the inland or sheltered waters are concerned and more or less normally to the North Temperature Zone, so far as the outer points and even whole ranges of the shores exposed to outer waters are concerned. The outer waters seem to be somewhat affected by the inland warmer waters in their immediate vicinity, however, because the northern species occurring in them either tend to grow in deeper water than they do north of the cape, or are often reduced, or even depauperate. It seems best, therefore, to regard the latitude of Provincetown, as Collins has done, to be the dividing line between the North Temperate and the North Subtropical Zones on the Atlantic coast of North America. The shores to the south, then, even including the deeper waters of Long Island Sound, show a very considerable admixture of northern species flourishing even during the season of normal maximum temperature. In this connection, attention may be called to the fact that the whole coast of New England lies between the mean maxima, or winter, temperatures of from 0° C. to 5° C. and is therefore subject to seasonal invasion, or, in the case of hardy perennial species, of winter or spring fruiting, of species normal to the Upper and Lower Boreal Zones. A discussion of these species would be of great interest, but is only of importance in a

discussion of details. Any attempt to enumerate the species according to the zones to which they are normal must necessarily take cognizance of this fact. This discussion has been intended only to deal with the relation of Cape Cod to the marine flora as a dividing line and I trust that this has been made even more definite than it has been demonstrated by previous writers.

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EXPLANATION OF PLATE 133.

Atlantic Coast of the United States from West Quoddy Head, near Eastport, Maine, south and southwest to just beyond Cape Hatteras, North Carolina, based upon "Sailing Chart, No. 100" of the U. S. Coast and Geodetic Survey. The continuous line running in towards the shore are the surface the isotheres of

15° C., 20° C., and 25° C., or lines of the isotherms of these degrees of temperature for the month of August. The broken lines running in towards the shore are the isocrymes of 5° C., 10° C., 15° C., and 20° C., or lines of the isotherms for the month of February. These two sets of isotherms show well the relation of Cape Cod to the average seasonal maxima and minima of the surface temperature of the waters of the coasts above and below it. I have prolonged the isotherm of 20° C. inward to the very coast itself and have attempted to sketch its deflection inward and northward as indicated by such data as to the temperature of the surface waters just offshore as are available. The deflection toward Long Island Sound and along the coast eastward to the shoals about Nantucket Island, thence northward to about Nauset on the eastern coast of the Cape Cod Peninsula, indicate the transition area lying between the North Temperate Zone above and the North Subtropical Zone below. In this transitional area, the outer coasts are of the North Temperate Zone while the inner are of the North Subtropical Zone. The dotted lines in Cape Cod Bay, in Vineyard Sound, and in Long Island Sound indicate that the isotherm of 20° C. passes below the surface at these places. The deflection of the 20° C. isotherm as sketched must be considered as only an approximate to accuracy in details. I have to thank my nephew, Charles E. Davis, and Miss. Ruth Jeanette Powell for preparing the map for reproduction.

SOME VARIETIES OF *PANICUM VIRGATUM*.

D. H. LINDER.

THERE has been considerable difficulty in separating from *Panicum virgatum* L. its var. *cubense* Griseb. or var. *obtusum* Wood. Wood's description¹ of the spikelet of the latter variety (from New Jersey) so closely matches the figure published by Hitchcock & Chase² of a spikelet from Grisebach's type of var. *cubense* that there is no doubt that the two varieties are identical. By Hitchcock & Chase the species and variety are separated in a general way by the size of the spikelets, the stoutness of the culms, and the shape of the panicle. Very little Cuban material has been examined, but such as has been studied closely matches the North Carolina and New Jersey plant referred to var. *cubense*. The appearance of the panicle is quite marked, the rays being fewer and farther apart than in typical *P. virgatum*, but the best criterion for the separation of the two is the spikelet. In the variety the lower glume is less than half the length of the spikelet and is broad and blunt, the second glume and the palea are about equal in length and are slightly exceeded by the lemma. The floral parts usually are appressed, giving the spikelet a cylindrical outline.

¹ Wood, *Botanist and Florist*, 392. 1874.

² Hitchcock & Chase, *North American Panicum*. *Contrib. U. S. Nat. Herb.* 15: 93. 1910.